IUFRO Working Group 2.08.03, 2011/11/14-18, Porto Seguro, Bahia State, Brazil : Communication orale qui n'a pas été retenue dans les actes

Near Infrared Spectroscopy and Eucalyptus wood properties

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AGRICULTURAL RESEARCH
FOR DEVELOPMENT

Jounal of Near Infrared Spectroscopy Volume 18 Issue 6 (2010)

Nirs publication for Eucalyptus = Pinus / 3

Toward global calibrations for estimating the wood properties of tropical, sub-tropical and temperate pine species
Laurence R. Schimleck,[a,*] Gary R. Hodge[b] and William Woodbridge[b]

Global near infrared models to predict lignin and cellulose content of pine wood
Gary R. Hodge and William C. Woodbridge

A multi-site, multi-species near infrared calibration for the prediction of cellulose content in eucalypt woodmeal
Geoff Downes,[a,b,*] Roger Meder[a,c] and Chris Harwood[a,b]

Utilisation of near infrared spectroscopy in *Pinus taeda* progeny tests located in southern Brazil
Laurence R. Schimleck,[a,*] Antonio R. Higa[b] and Jorge L.M. Matos[b]

Classification of pernambuco (*Caesalpinia echinata* Lam.) wood quality by near infrared spectroscopy and linear discriminant analysis
Monica Casale,[a] Laurence R. Schimleck[b,c,*] and Charles Espey[d]

Resonance and near infrared spectroscopy for evaluating dynamic wood properties
Paulo Ricardo Gherardi Hein,[a] Loïc Brancheriau,[a] Paulo Fernando Trugilho,[b] José Tarcísio Lima[b] and Gilles Chaix[c]

Predicting microfibril angle in *Eucalyptus* wood from different wood faces and surface qualities using near infrared spectra
Paulo R.G. Hein,[a,*] Bruno Clair,[b] Loïc Brancheriau[a] and Gilles Chaix[c]

A portable method to estimate wood basic density from increment cores using spectroscopic techniques
Cristóbal Galleguillos-Hart,[a] M. Paulina Fernández[b] and Andrés Guesalaga[a]

Near infrared hyperspectral imaging applied to mapping chemical composition in wood samples
Armin Thumm,[a] Marc Riddell,[a] Bernadette Nanayakkara,[a] Jonathan Harrington[a] and Roger Meder[b]

Applied Spectroscopy Reviews, 42: 43–71, 2007

ISSN 0570-4928 print/1520-569X online
DOI: 10.1080/05704920601036707

Taylor & Francis
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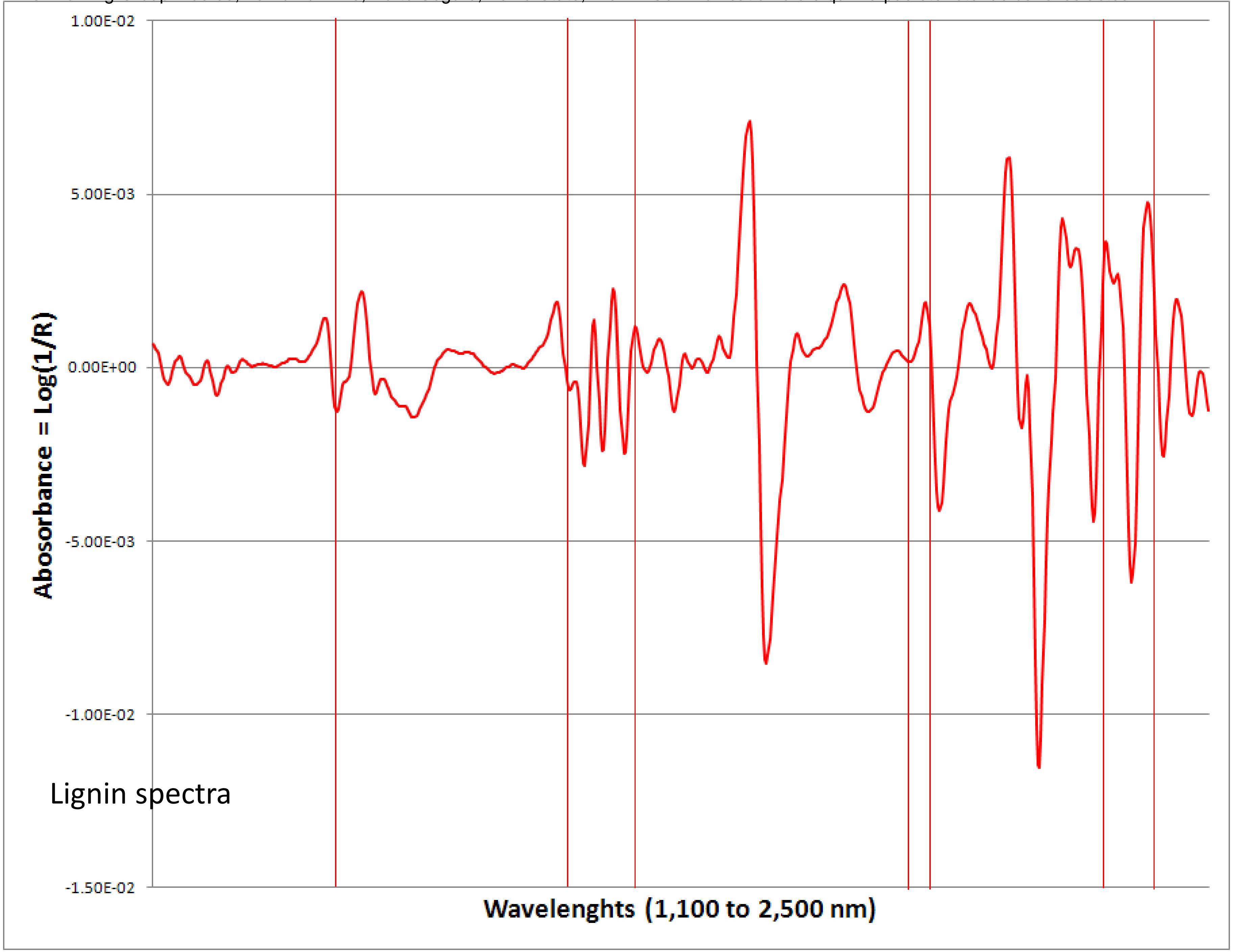
A Review of Recent Near Infrared Research for Wood and Paper

Satoru Tsuchikawa


1.00E-02
5.00E-03
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-5.00E-03
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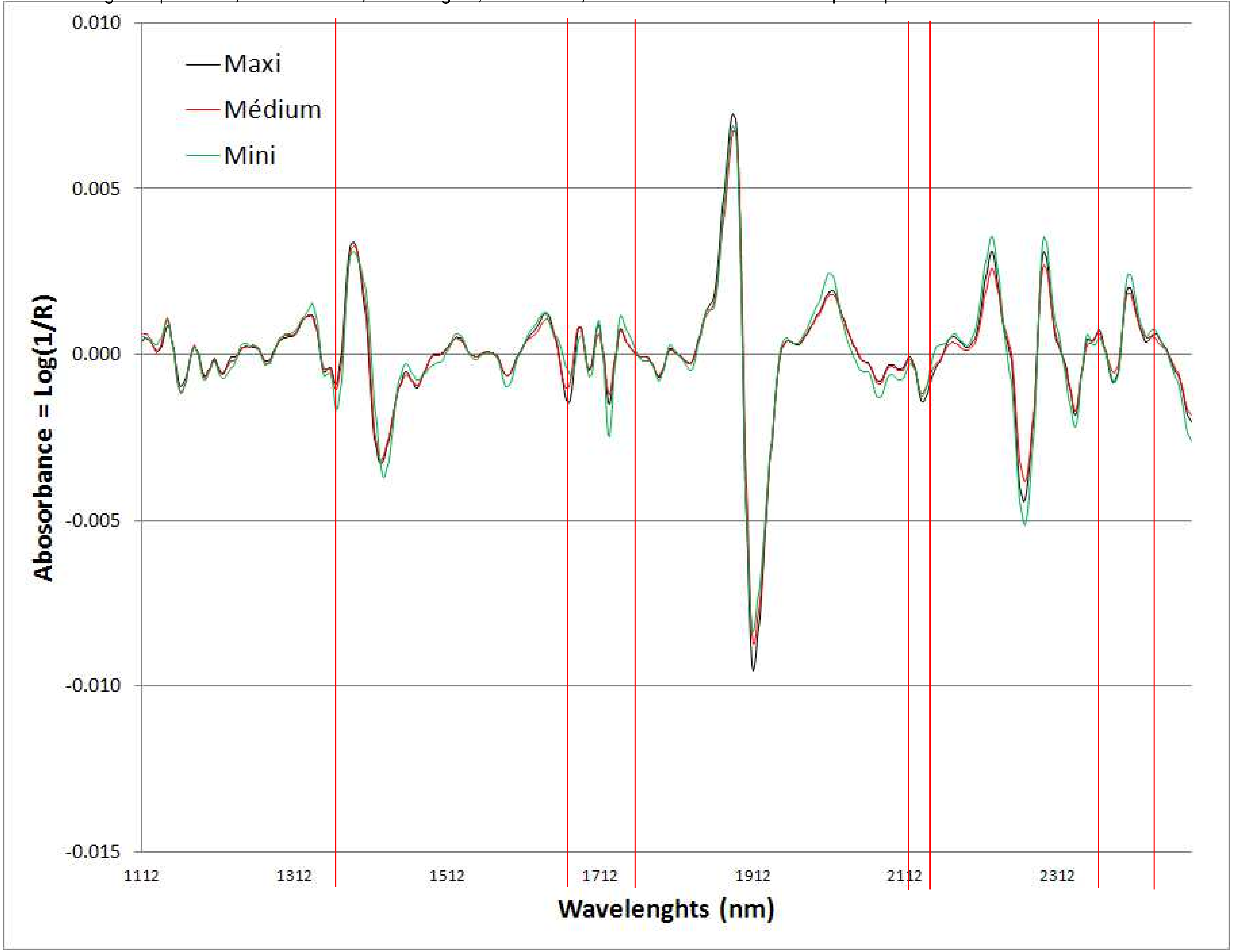
-1.50E-02
Abosorbance = Log(1/R)
Wavelenghts (1,100 to 2,500 nm)
Lignin spectra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Abosorbance = Log(1/R)
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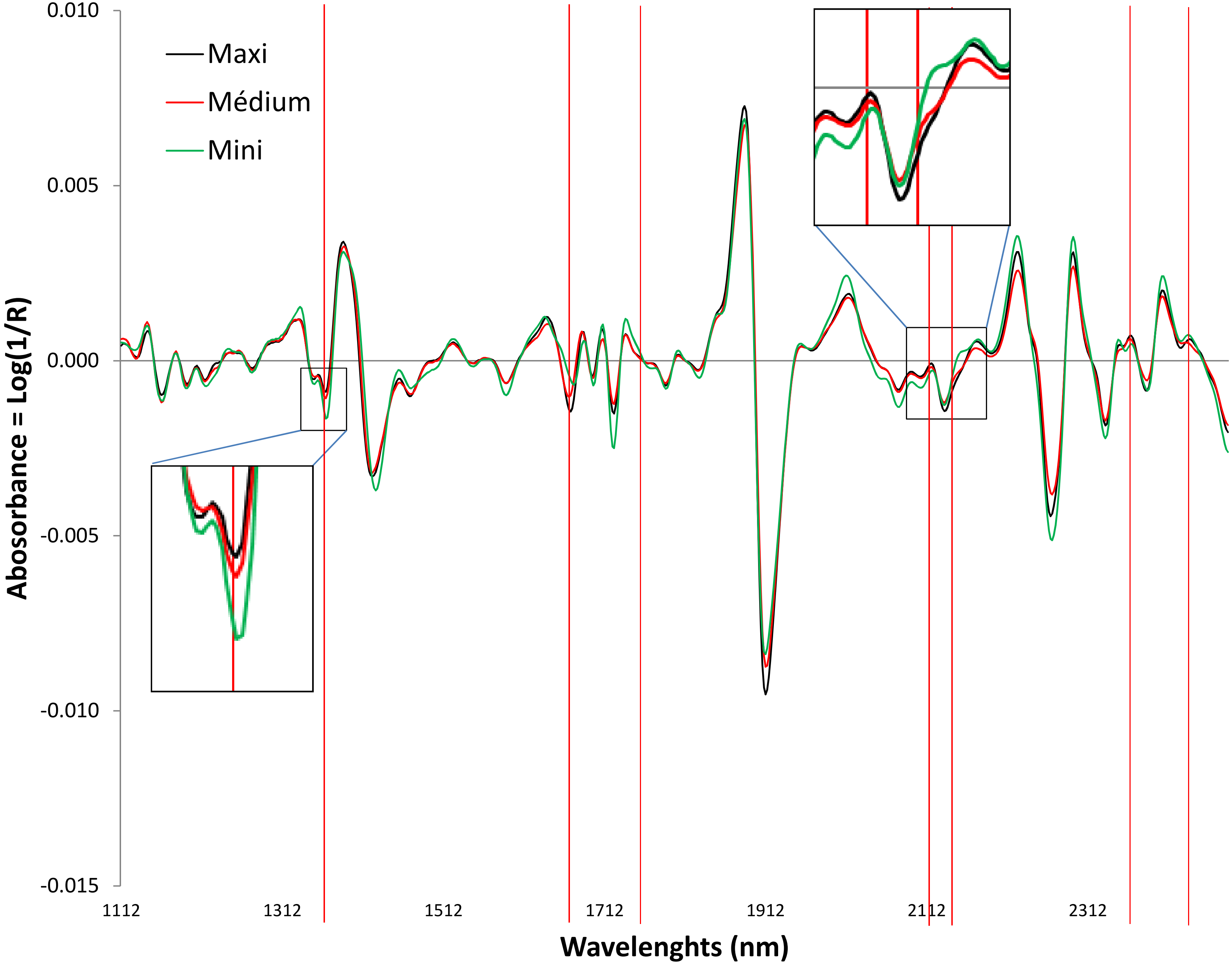
Wavelenghts (nm)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Abosorbance = Log(1/R)
1112
1312
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1912
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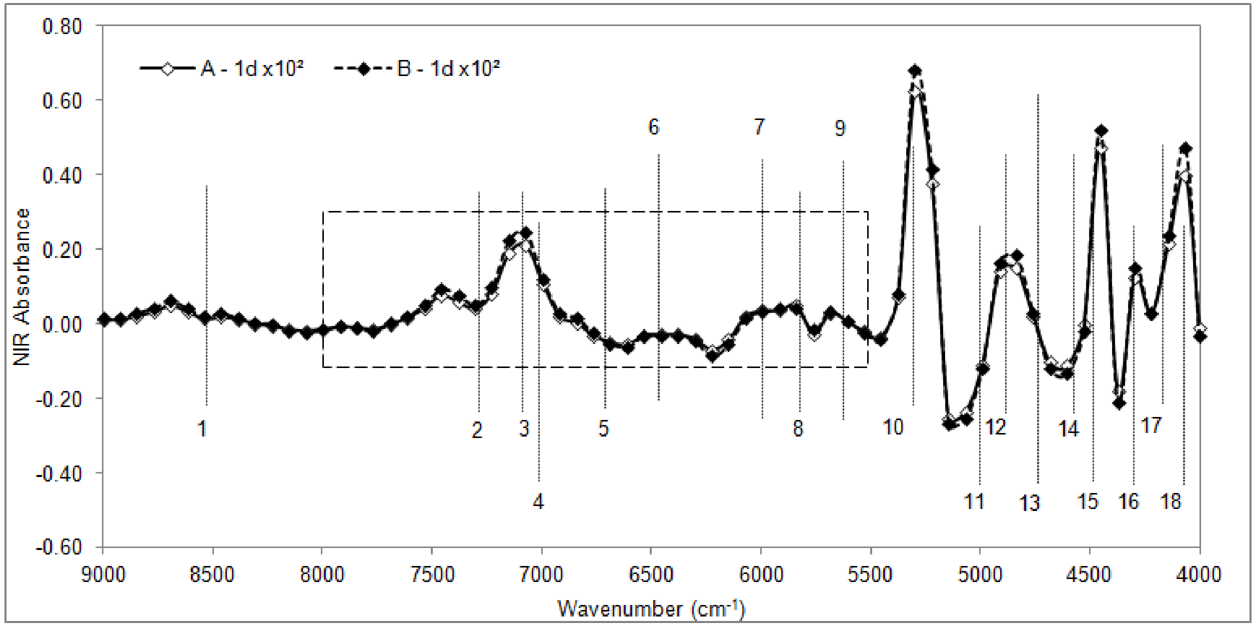
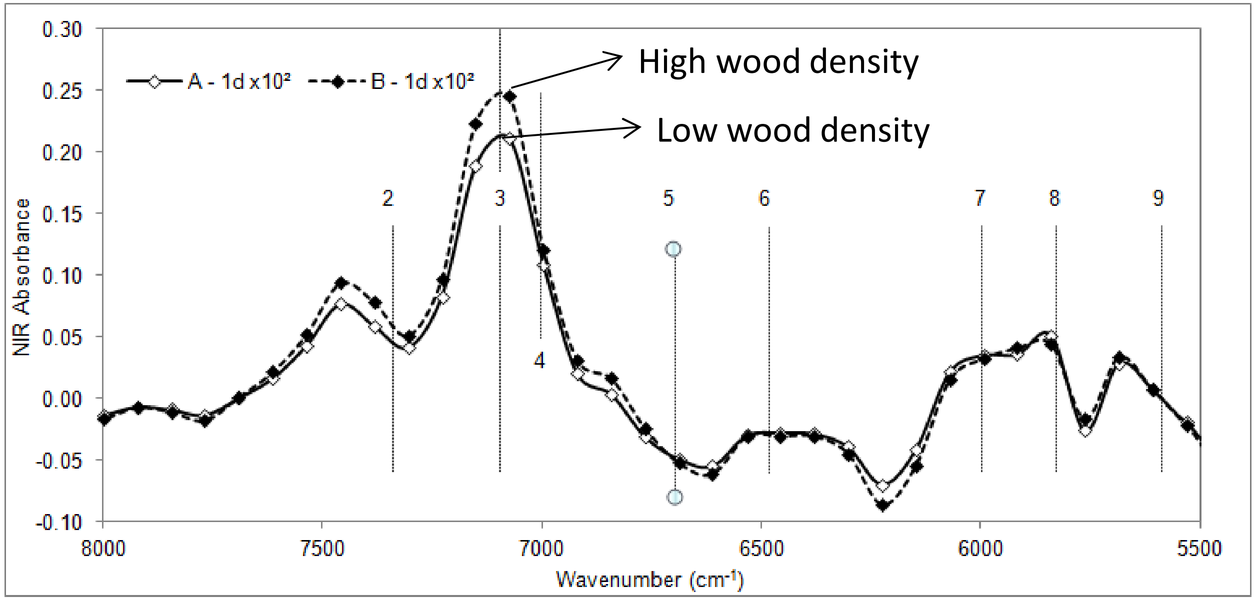
Wavelenghts (nm)

NIR spectra recorded on radial surface of wood (from Hein 2011)





Nirs tool for wood trait assessments in Cirad

Chemical properties:

- Lignin contents (Klason, S, G, S/G)
- Total extractives
- Polyphenol related to color, durability, ...)
- Cellulose

Physical properties:

- Shrinkage
- Natural durability
- Density
- MFA

Wood product properties:

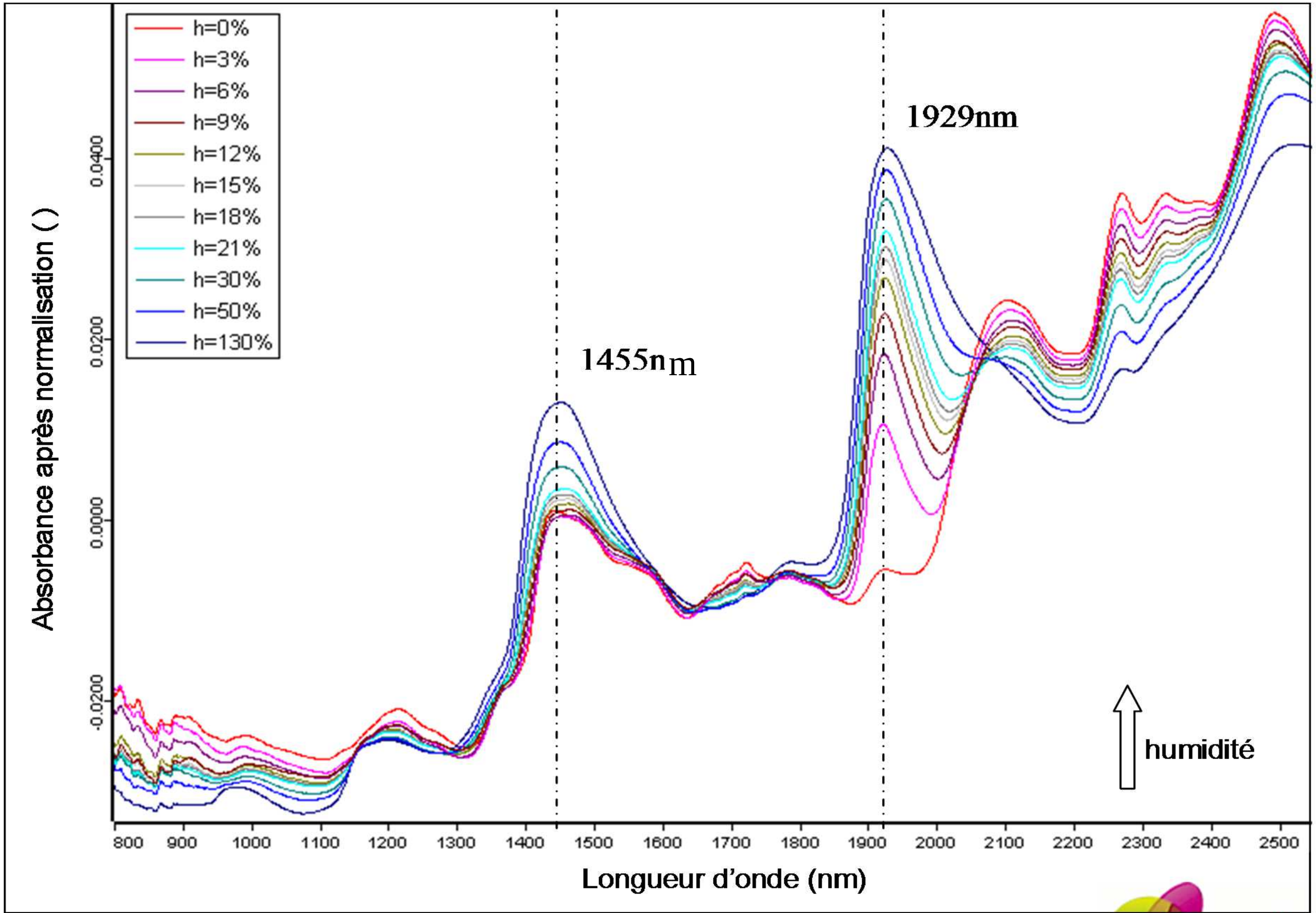
- Pulp yield
- Charcoal yield
- Particle board properties

Inputs of Nirs tool for:

- Genetic and environmental controls
- Gene expression studies
- Genetic improvement and variety productions on wood quality

➔ High throughput phenotyping

Control of NIR process - 1



Control of NIR process - 2

Apparatus controls

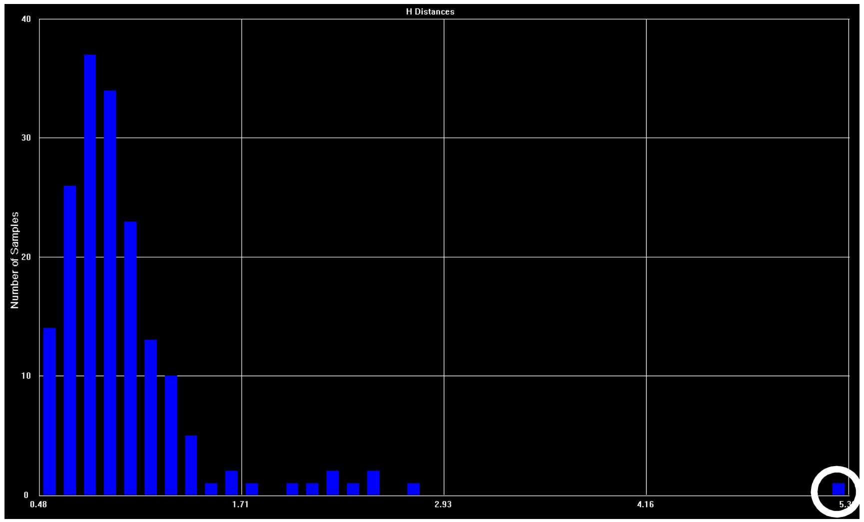
Internal & external reference, check-cell, sequency control (hours, day, ...)

Repeatability/apparatus same sample x times / RMS

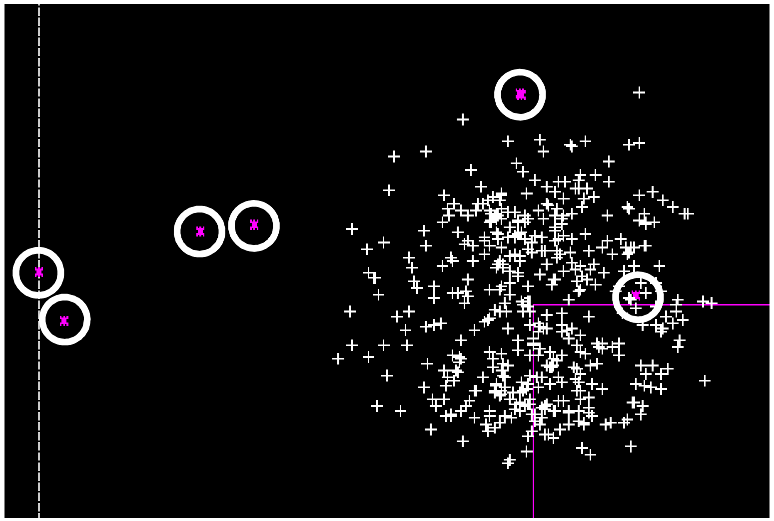
Spectral data (raw spectra and treated spectra)

Control all spectra and detect outliers, cluster, spread

PCA, % of variability explined by PC



Mahalanobis distance



PC2

PC1

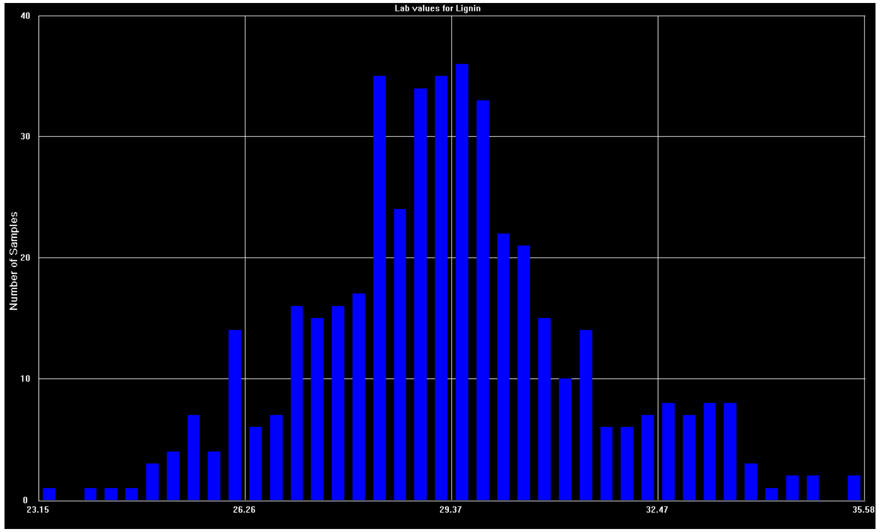
Control of NIR process - 3

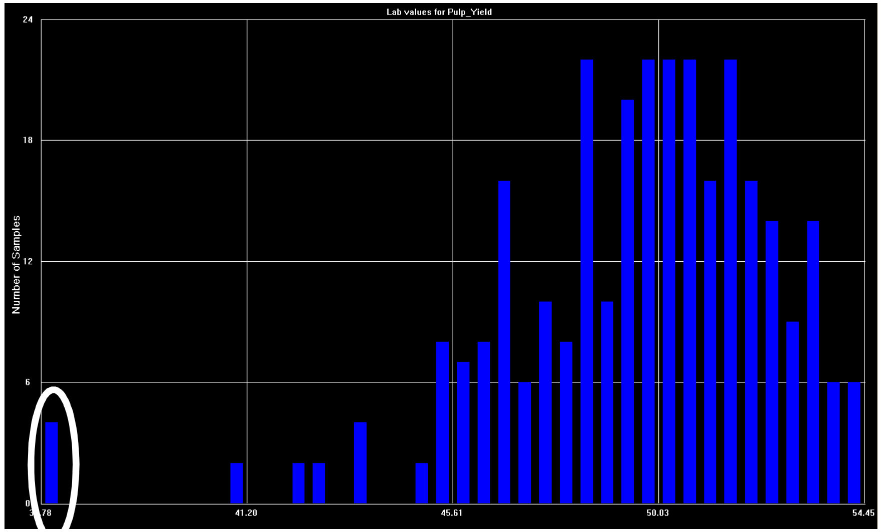
Laboratory data

Spread (mean, SD, min, max)

Distribution (histogram one by one)

Correlation (Y_1 vs Y_2, ...)



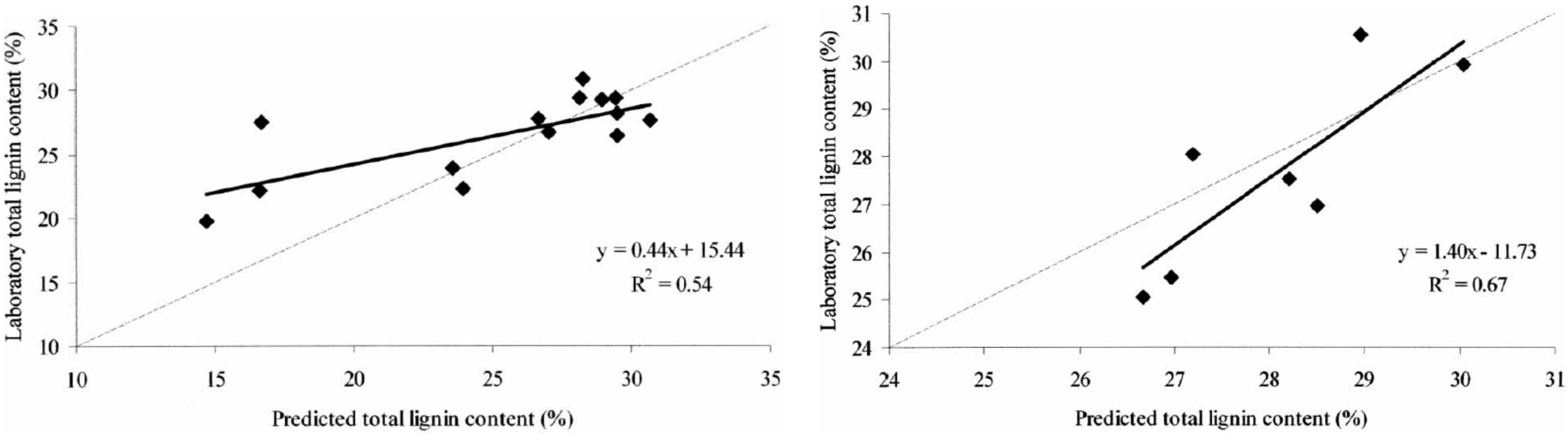


Repeatability of reference method

Standard Error of Laboratory (SEL)

Drift effect of accuracy, apparatus, and manpower effect, ...

What you don't accept



Wood component	Number of factors	R^2	SEC
Extractives content	6	0.84	1.37
Acid-soluble lignin content	6	0.72	0.41
Klason lignin content	4	0.78	1.02
Total lignin content	4	0.76	1.07
Cellulose content	5	0.88	1.14

What you have to receive

RPD = SD/SEP

Prediction value $^{+}/_{-}$ 2 * SEP

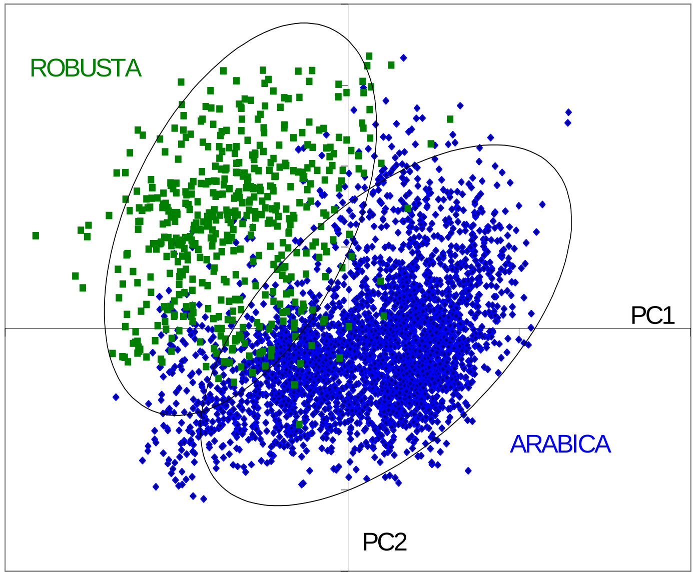
	Constituent	N	Mean	SD	SEC	R^2	SECV	SEP	SEL	RPD
ROBUSTA	Dry Matter	259	92.4	2.37	0.09	0.99	0.12	0.13	0.10	18.2
	Cafein	330	2.56	0.43	0.08	0.96	0.08	0.08	0.06	5.4
	Trigonelline	200	0.79	0.09	0.05	0.62	0.06	0.06	0.03	1.5
	Sucrose	108	4.87	0.89	0.34	0.85	0.47	0.48	0.40	1.9
	Chlorogenic Acids	169	11.7	1.12	0.46	0.85	0.53	0.53	0.30	2.1

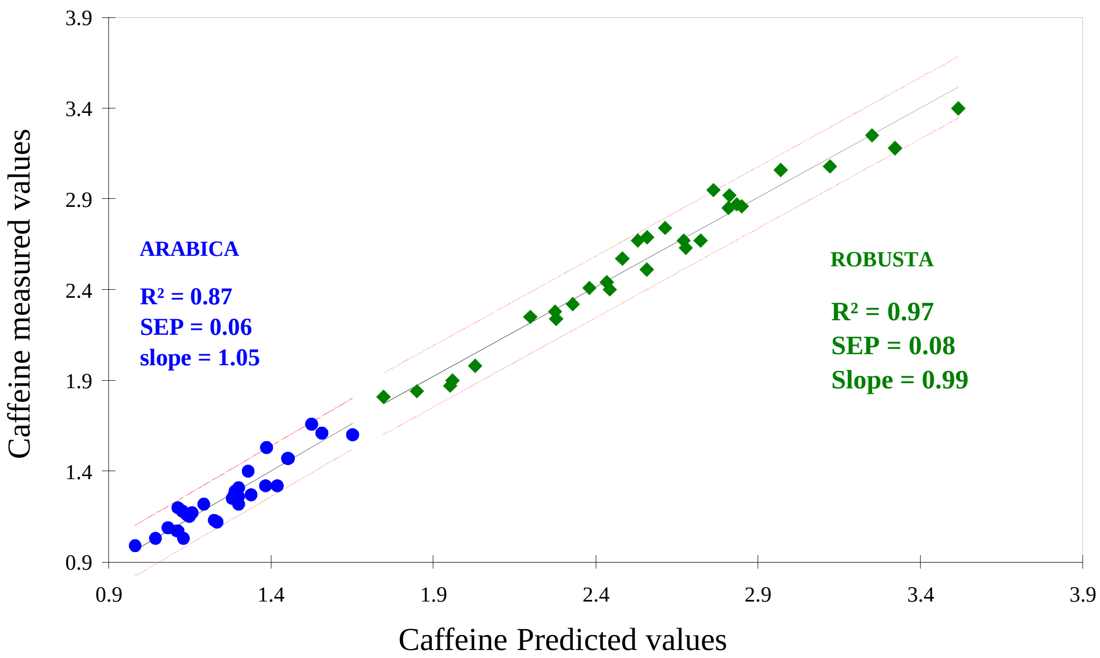
(Davrieux, com. Pers.)

Criteria	N	M	SD	SEC	R^2	SECV	SEL	SEP	Number of PLS terms	RPD
EC (%)	186	3.66	0.58	0.29	0.75	0.35	0.34	0.29	8	2
KL (%)	189	24.62	0.84	0.30	0.87	0.34	0.42	0.32	6	2.6
S/G ratio	186	4.03	0.54	0.17	0.90	0.20	0.08	0.18	7	3

Baillères 2002

What you have to receive





Nirs and basic density of Eucalyptus wood

Validation = independent validation

P.R.G. Hein, J.T. Lima and G. Chaix, *J. Near Infrared Spectrosc.* **17**, 141–150 (2009) 141
Received: 18 February 2009 ■ Revised: 18 May 2009 ■ Accepted: 22 May 2009 ■ Publication: 1 June 2009

JNIRS JOURNAL OF NEAR INFRARED SPECTROSCOPY

Robustness of models based on near infrared spectra to predict the basic density in *Eucalyptus urophylla* wood

Paulo Ricardo Gherardi Hein,[a,*] José Tarcísio Lima[b] and Gilles Chaix[c]

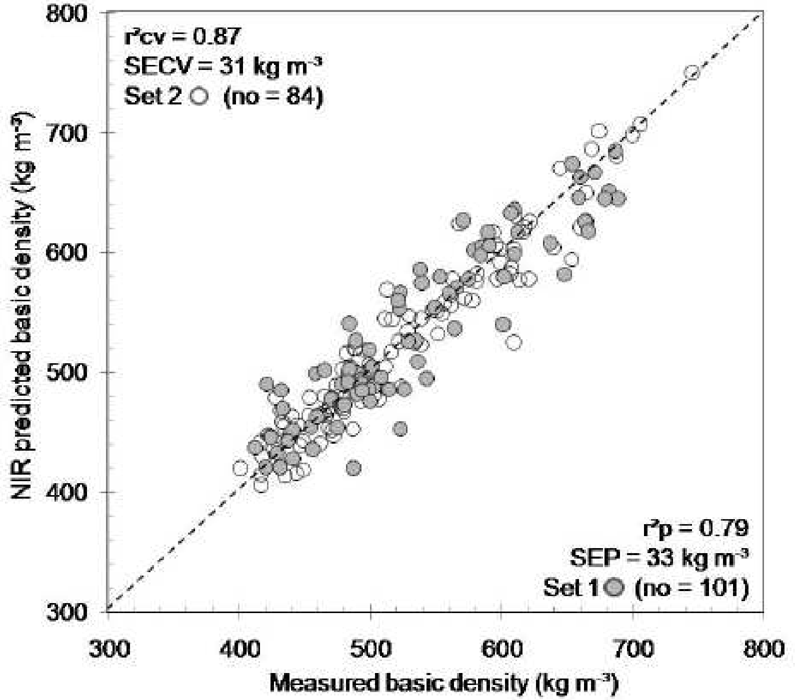


Figure 4. NIR predicted versus measured values for basic density. The original NIR spectra from data set 2 were used for calibration and those from data set 1 for validation.

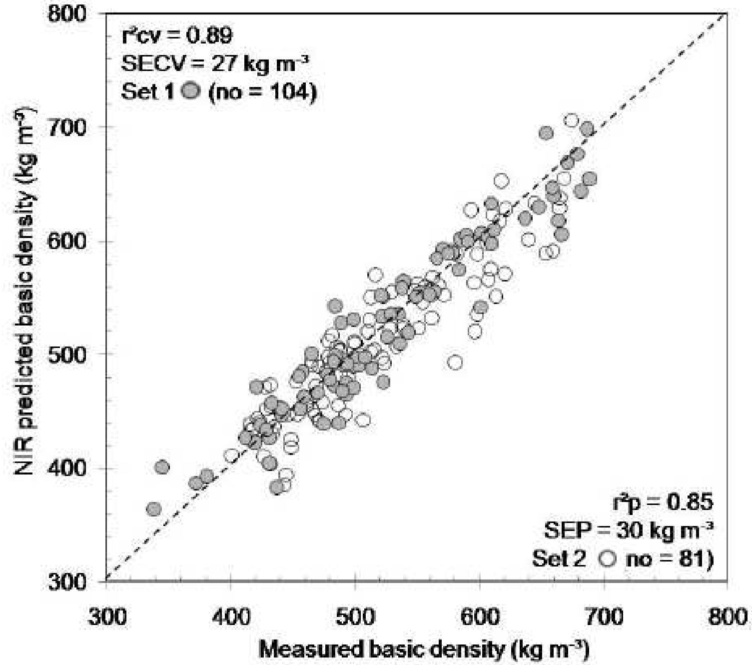
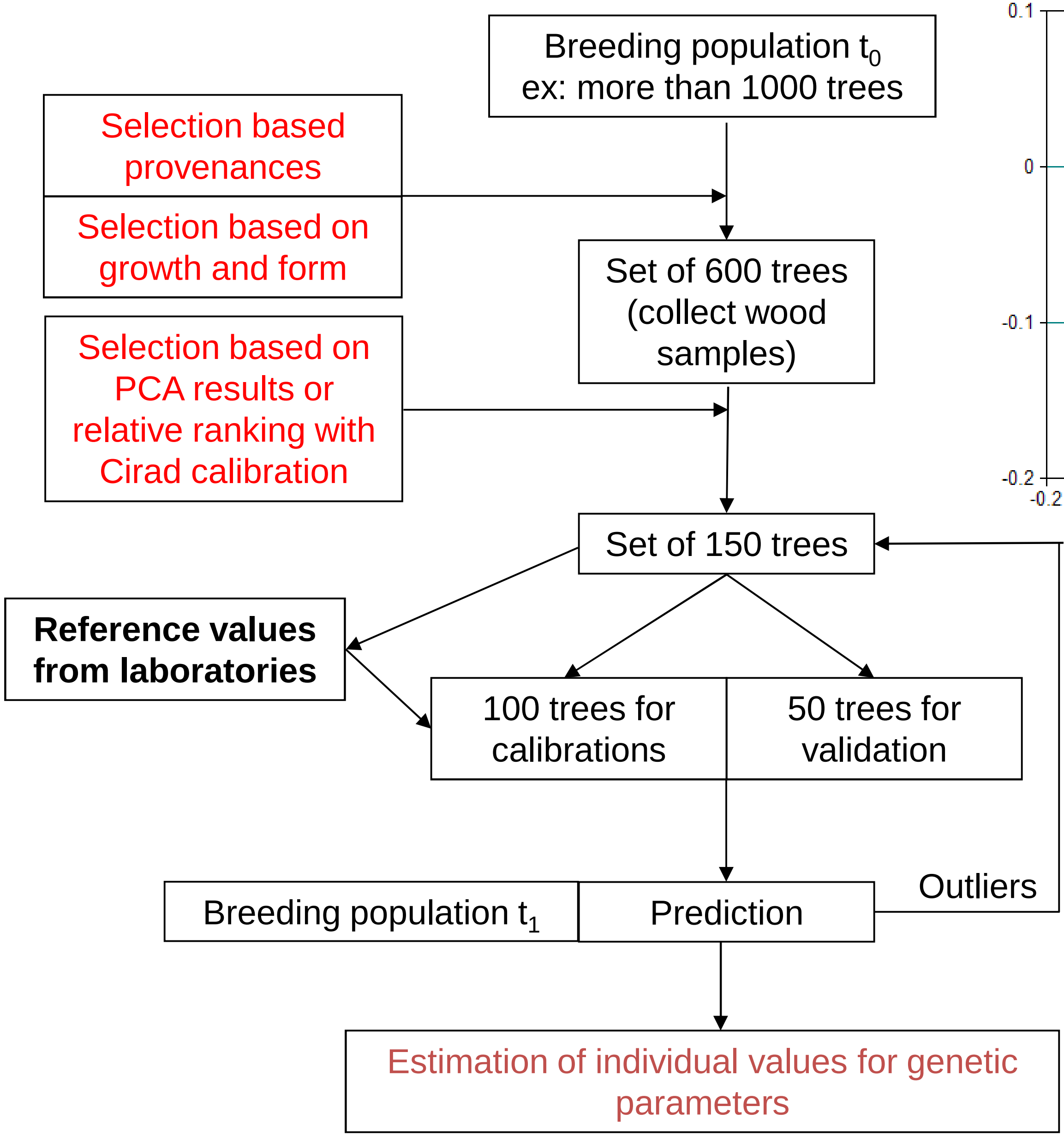
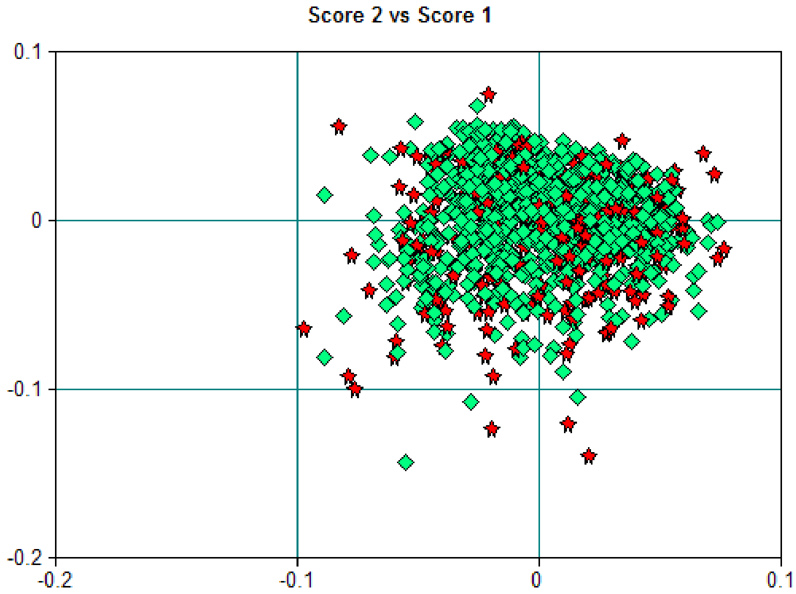


Figure 3. NIR predicted versus measured values for basic density. The original NIR spectra from data set 1 were used for cross-validation and those from data set 2 for independent validation.

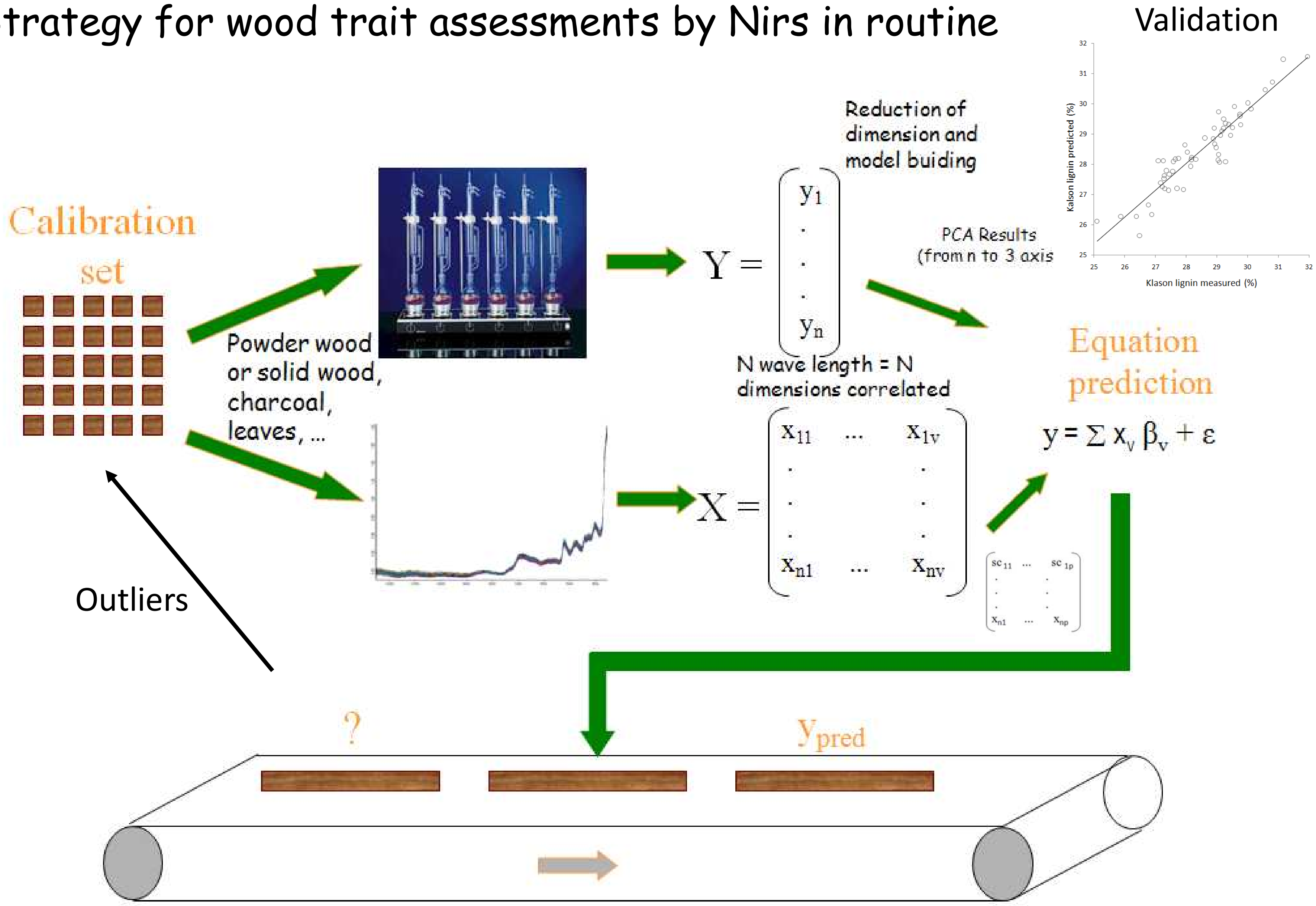
IUFRO Working Group 2.08.03, 2011/11/14-18, Porto Seguro, Bahia State, Brazil : Communication orale qui n'a pas été retenue dans les actes

Sampling and Nirs strategy for genetic studies

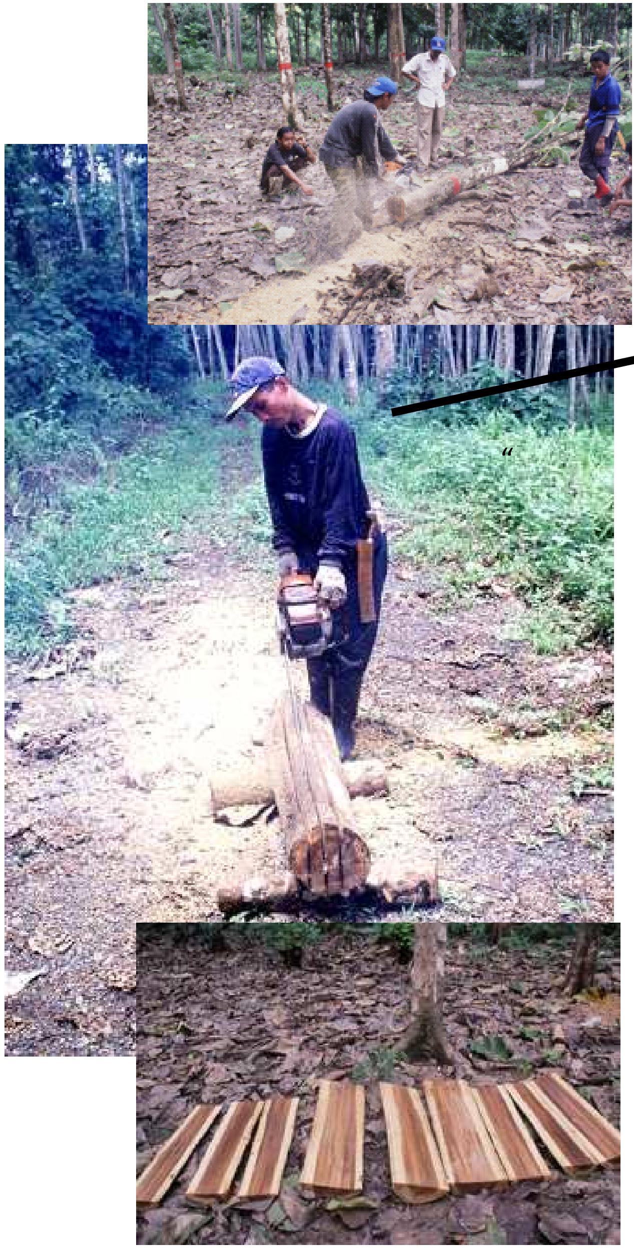


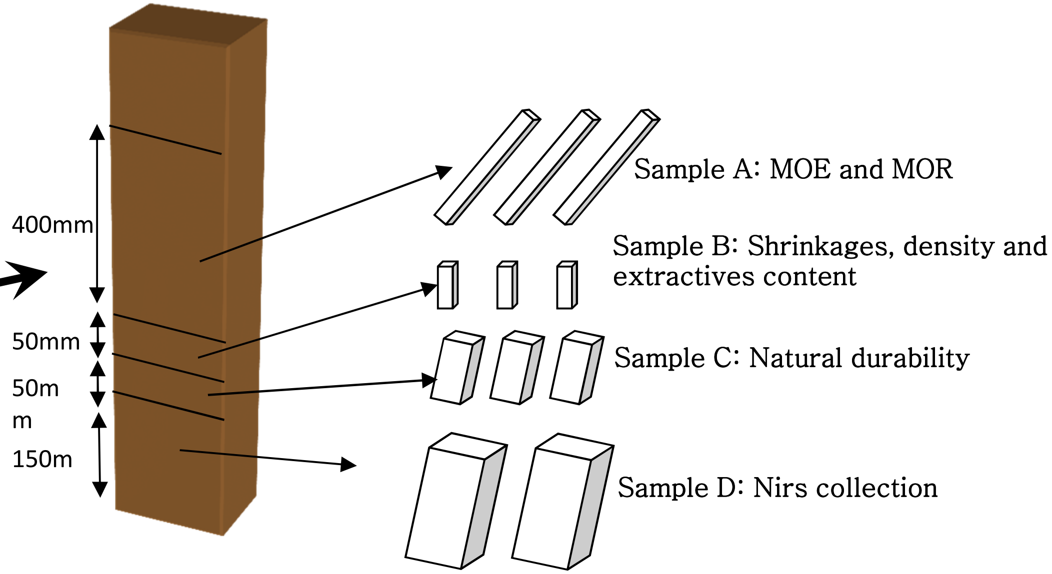


Strategy for wood trait assessments by Nirs in routine



Destructive wood sampling process for reference analysis



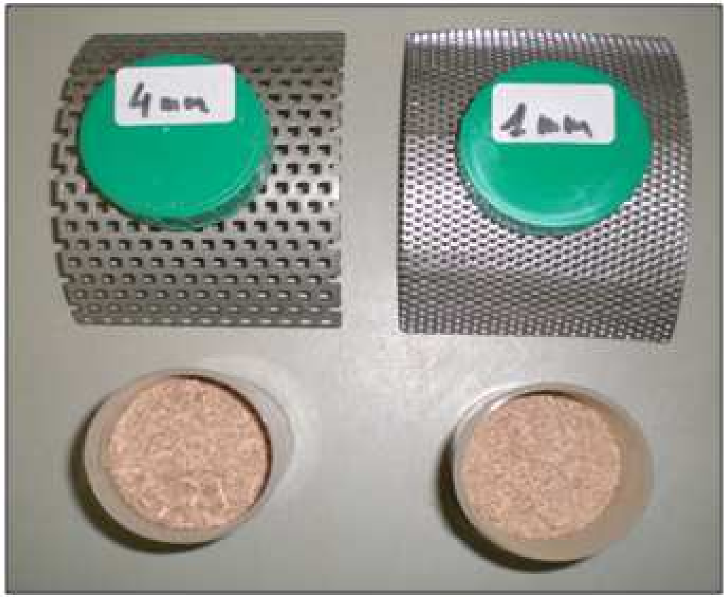


Reference analysis

Non destructive wood sampling for some reference analysis and NIRS prediction

Non destructive wood sampling for some reference analysis and NIRS prediction

Type of wood samples – NIRS

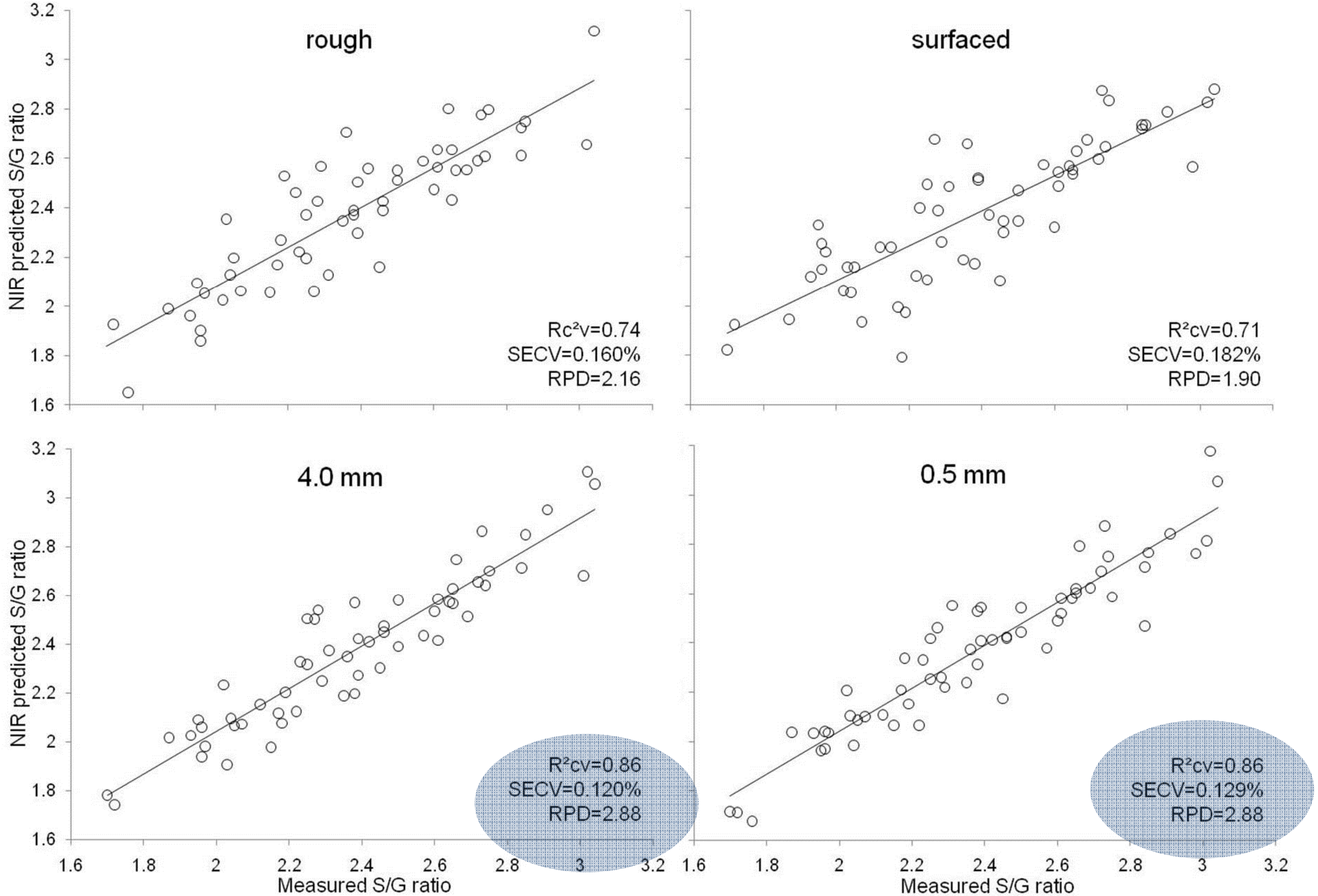


Type of wood samples – NIRS

Effects of sample preparation on NIR spectroscopic estimation of chemical properties of *Eucalyptus urophylla* S.T. Blake wood

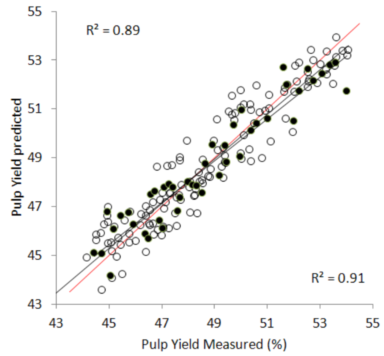
Paulo Ricardo Gherardi Hein[1,*], José Tarcísio Lima[2] and Gilles Chaix[3]

Holzforschung, Vol. 64

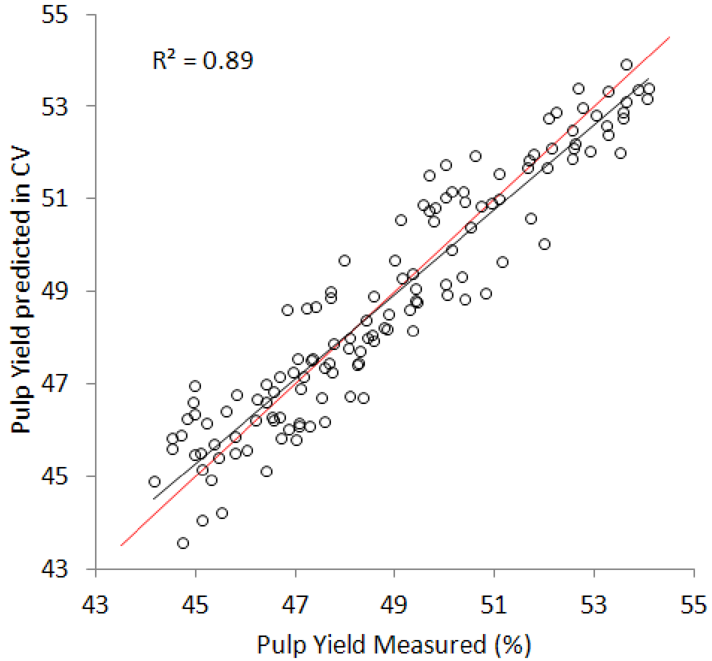


Results of validations for some Nirs Models

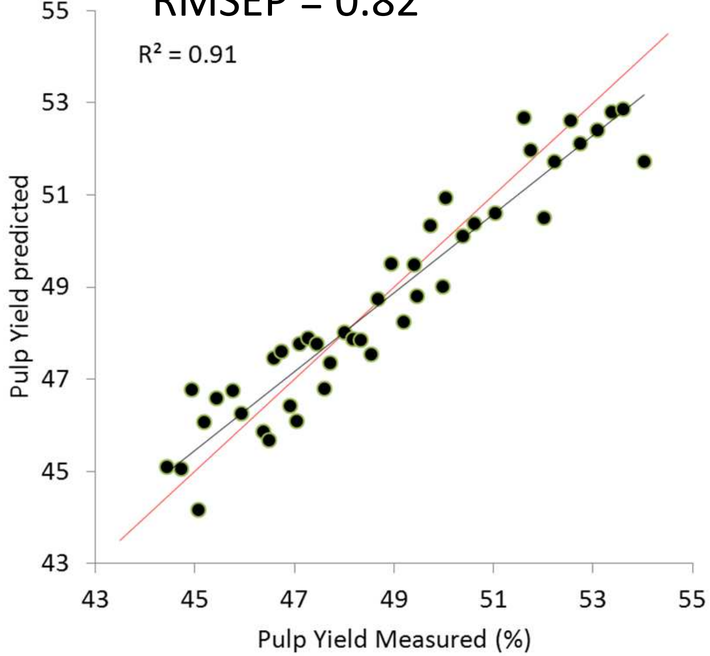
Pulp yield, E. pellita (APP indonesia)



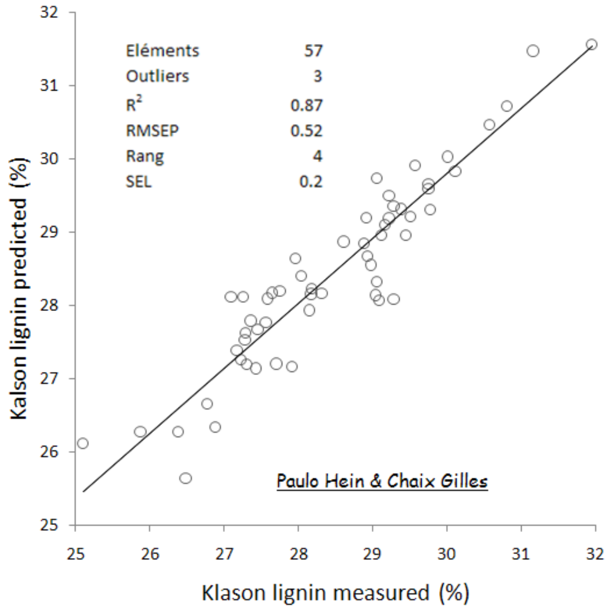
N= 136
RMSECV = 0.88



N=44
RMSEP = 0.82



Nirs and eucalyptus wood – Lignin content, S/G ratio



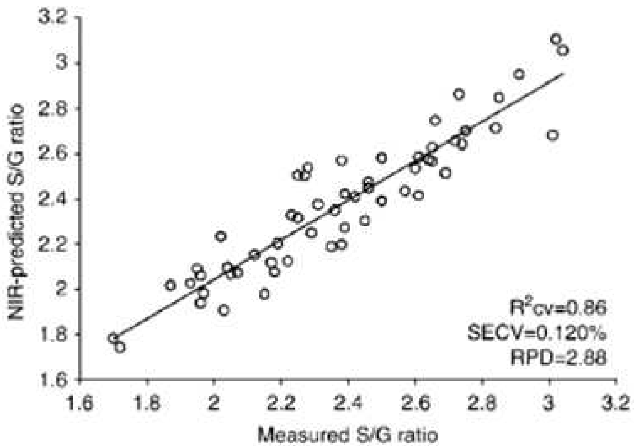


Figure 4 Measured versus NIR predicted plot for syringyl-to-guaiacyl ratio in *Eucalyptus urophylla* wood.

Hein Paulo & Chaix Gilles

Near infrared analysis as a tool for rapid screening of some major wood characteristics in a eucalyptus breeding program

Ann. For. Sci. 59 (2002) 479–490

Henri Baillères[a*], Fabrice Davrieux[a] and Frédérique Ham-Pichavant[b]

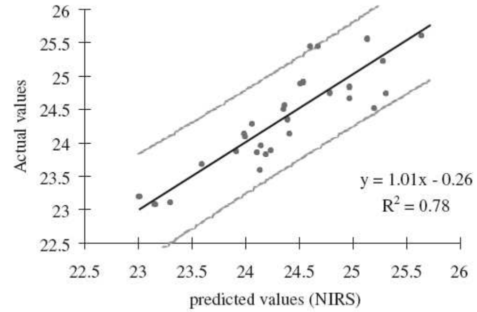


Figure 4. Correlation between laboratory values and NIRS predicted values (nonextracted disk samples) for KL content, obtained for a set of 30 independent samples (95% confidence interval).

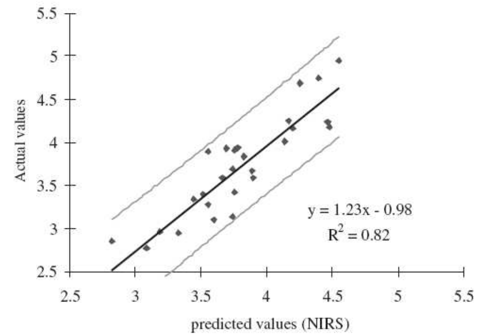


Figure 6. Correlation between laboratory values and NIRS predicted values (extractive-free disk samples) for EC, obtained for a set of 28 independent samples (95% confidence interval).

Nirs and basic density of Eucalyptus wood

P.R.G. Hein, J.T. Lima and G. Chaix, *J. Near Infrared Spectrosc.* **17**, 141–150 (2009) 141
Received: 18 February 2009 ■ Revised: 18 May 2009 ■ Accepted: 22 May 2009 ■ Publication: 1 June 2009

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Robustness of models based on near infrared spectra to predict the basic density in *Eucalyptus urophylla* wood

Paulo Ricardo Gherardi Hein,[a,*] José Tarcísio Lima[b] and Gilles Chaix[c]

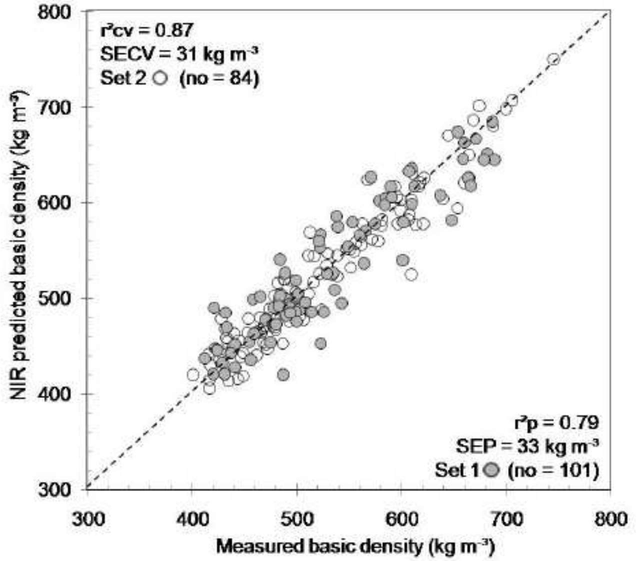


Figure 4. NIR predicted versus measured values for basic density. The original NIR spectra from data set 2 were used for calibration and those from data set 1 for validation.

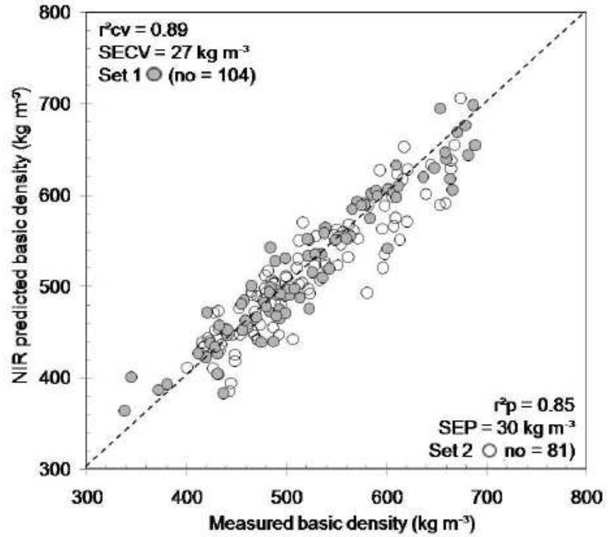


Figure 3. NIR predicted versus measured values for basic density. The original NIR spectra from data set 1 were used for cross-validation and those from data set 2 for independent validation.

SCIENTIA FORESTALIS

Estimativa da resistência e da elasticidade à compressão paralela às fibras da madeira de *Eucalyptus grandis* e *E. urophylla* usando a espectroscopia no infravermelho próximo

Estimation of the strength and elasticity in compression parallel to fibers to grain of *Eucalyptus grandis* and *E. urophylla* wood, using near infrared spectroscopy

Paulo Ricardo Gherardi Hein[1], Ana Carolina Maioli Campos[2], José Tarcísio Lima[3], Paulo Fernando Trugilho[4] e Gilles Chaix[5]

NEAR INFRARED SPECTROSCOPY FOR ESTIMATING WOOD BASIC DENSITY IN *Eucalyptus urophylla* AND *Eucalyptus grandis*

Paulo Ricardo Gherardi Hein[1], Ana Carolina Maioli Campos[2], Paulo Fernando Trugilho[3], José Tarcísio Lima[3], Gilles Chaix[4]

Cerne, Lavras, v. 15, n. 2, p. 133-141

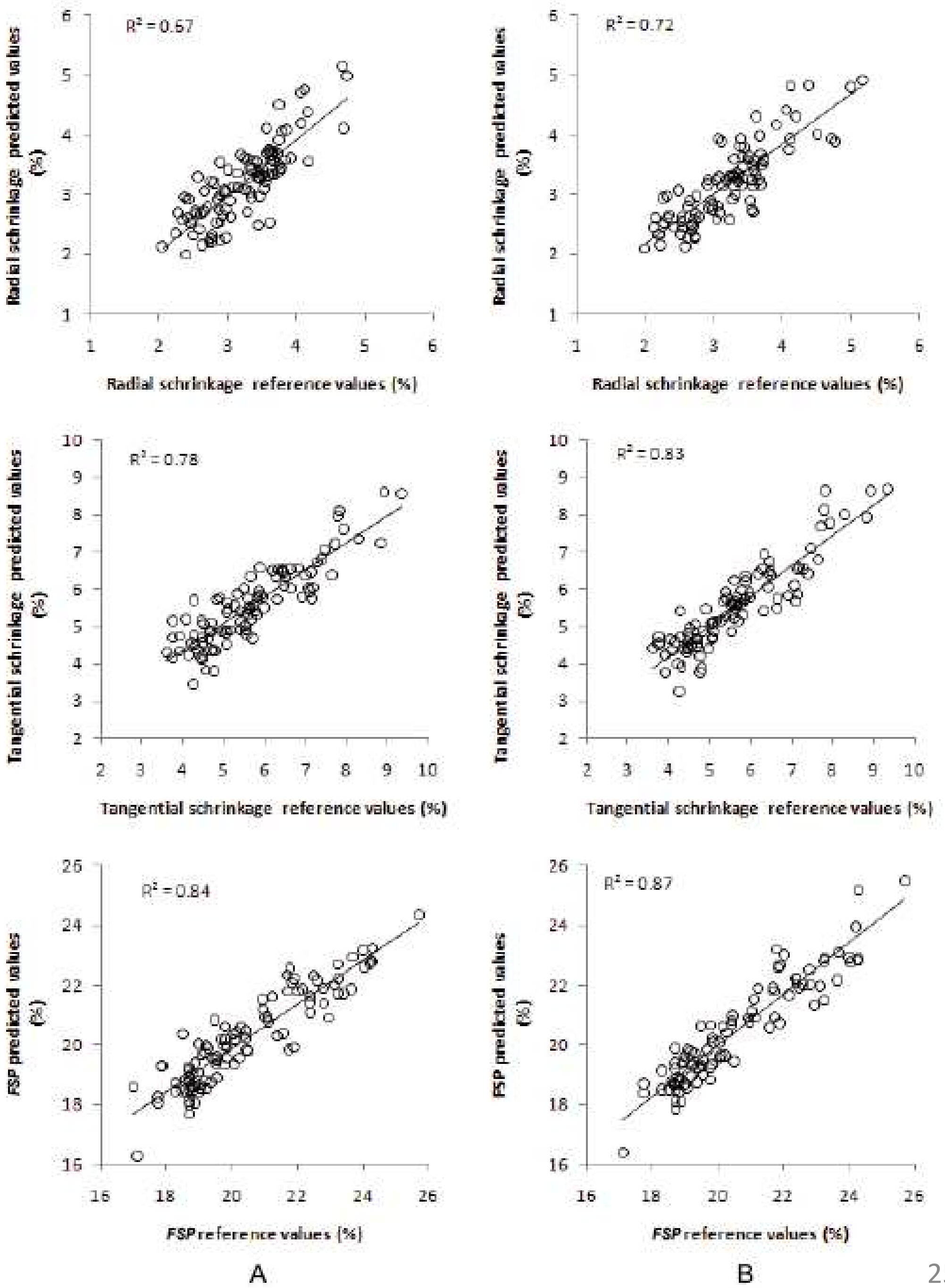
Nirs and tectona grandis wood – schrinkage and FSP

Nir cross section	Schrinkage/ PSF		**SEP**	**R^2**	**RPD**
Tang	Radial	D2	0.31	0.79	2.1
	Tangential	D2	0.58	0.83	2.4
	PSF	D1	0.78	0.81	2.2
Longi	Radial	D1 + Snv	0.31	0.77	2.1
	Tangential	D1 + Snv	0.58	0.81	2.3
	PSF	D2 + Snv	0.59	0.90	3.1

Rapid prediction of shrinkage and fibre saturation point on teak (*Tectona grandis*) wood based on near-infrared spectroscopy

Adzo-Dzifa KOKUTSE[1], Loïc BRANCHERIAU[2], Gilles CHAIX[3*]

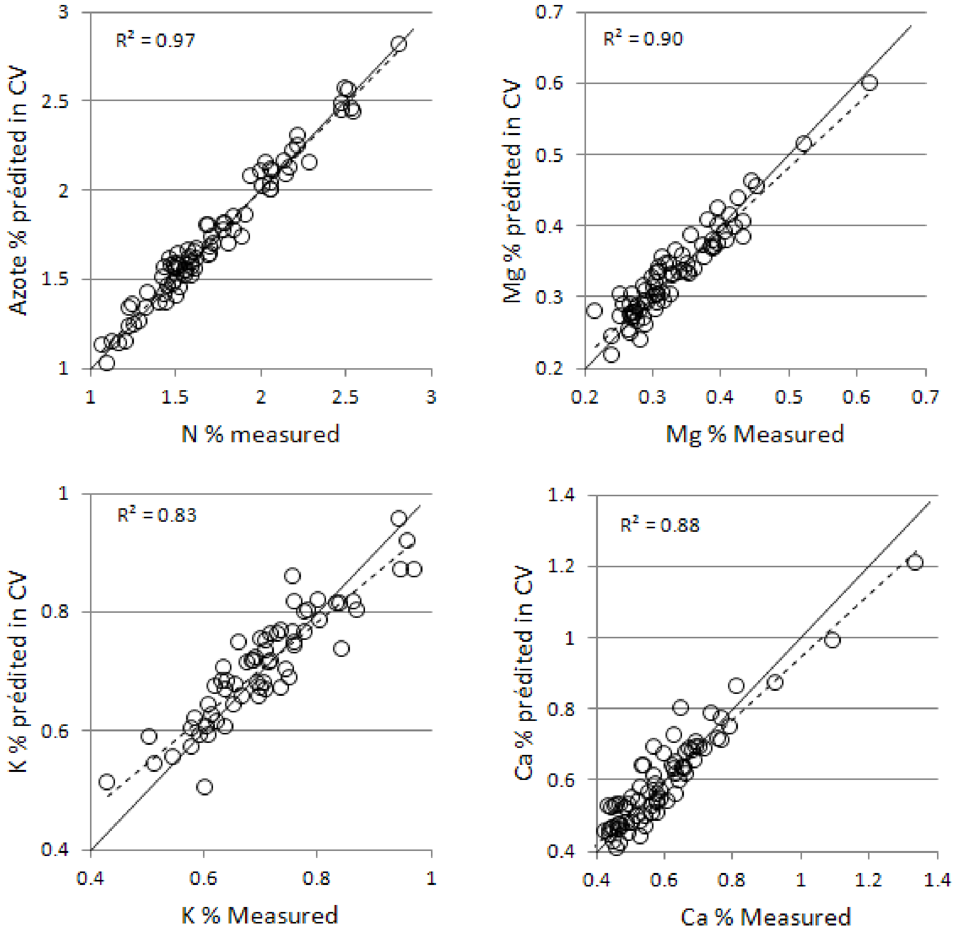
Ann. For. Sci. 67 (2010) 403



Kokutse, Brancheriau & Chaix

NIR and nutriments in Eucalyptus leaves

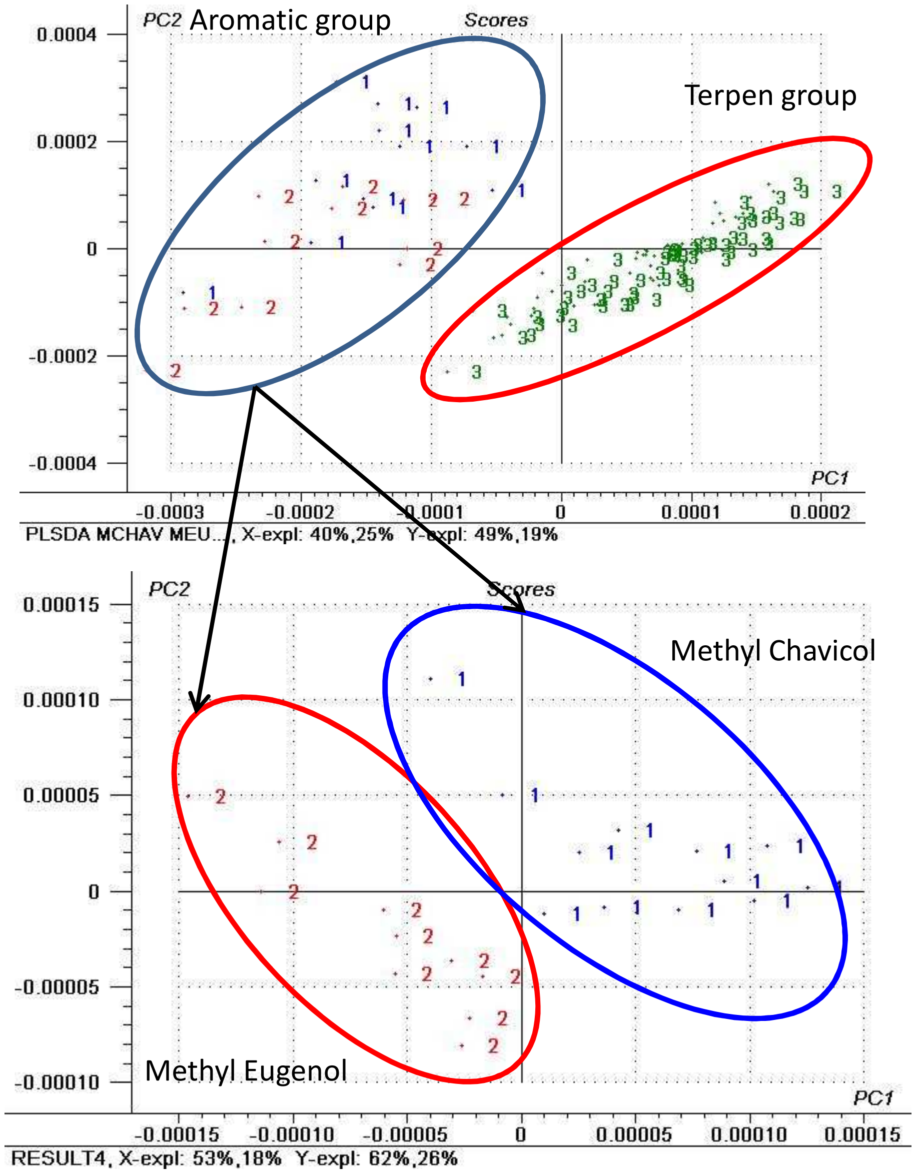
Elements	Unis	N	Outliers	Means	SD	Min	Max	SECV	R^2cv	RPD	LV
N	% MS	80	0	1.73	0.39	1.08	2.82	0.069	0.97	5.6	4
Mg	% MS	80	5	0.33	0.07	0.22	0.62	0.022	0.90	3.1	8
K	% MS	80	17	0.71	0.11	0.432	0.97	0.045	0.83	2.4	4
Ca	% MS	80	1	0.59	0.15	0.39	1.34	0.053	0.88	2.8	9



Nirs detection of chemotypes of *Ravensara aromatica*

Nirs on dried leaves
3 groups corresponding to 3 essential oil types

PLS-DA : Discriminate analysis basesd on Partial Least-Squares Regression



Andrianoelisoa & Chaix in prep.

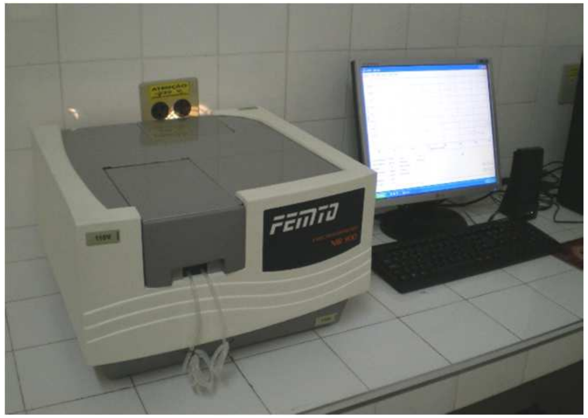
Conclusions

Nirs inputs for phenotyping

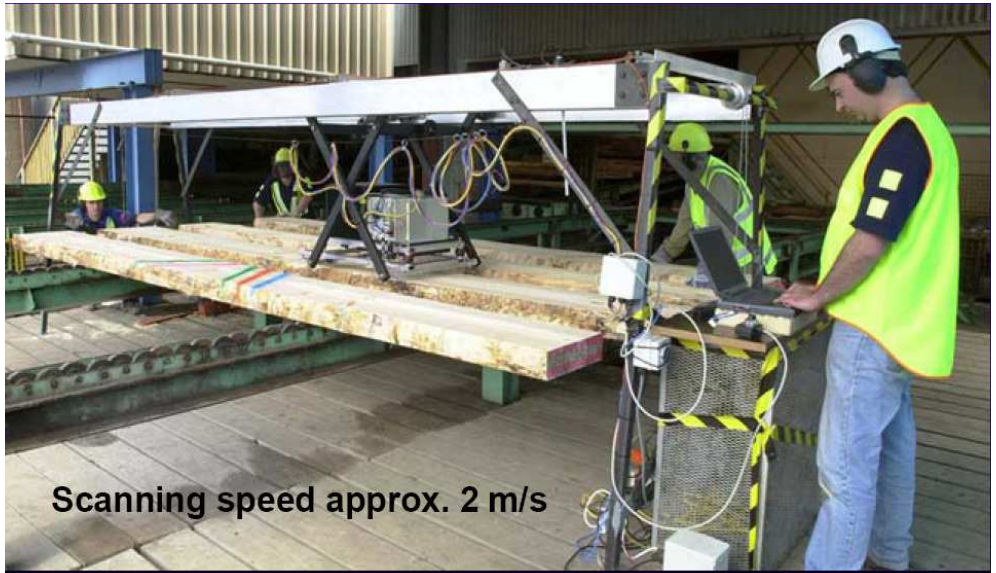
- Large number of measures for genetic studies, selection, …, environment effect, but sampling and conditioning of samples too long
- 100 to 1,000 samples
- Including equipment cost, Nirs cheaper vs costly and time-consuming measurements
- Large type of properties and sample types

The future

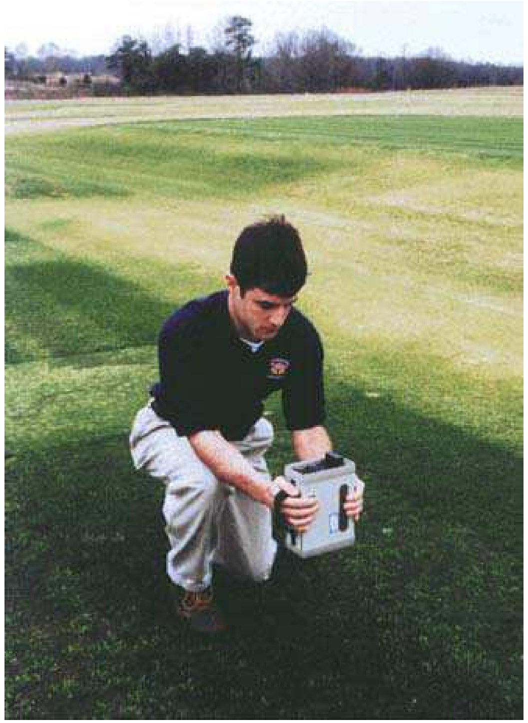
- Sampling for more sample per day
- 1,000 – 1,0000 samples
- Micro-samples vs representative estimations?
- Nirs measurement in the field requires correction for moisture content variation
- For a better understanding of wood formation hyperspectral imaging and Nirs microscopy


FEMTO


TANGO



Picture courtesy A. Thumm and R. Meder, Forest Research, New Zealand




CAE


TOPLINER
DEUTZ-FAHR


BRIMROSE